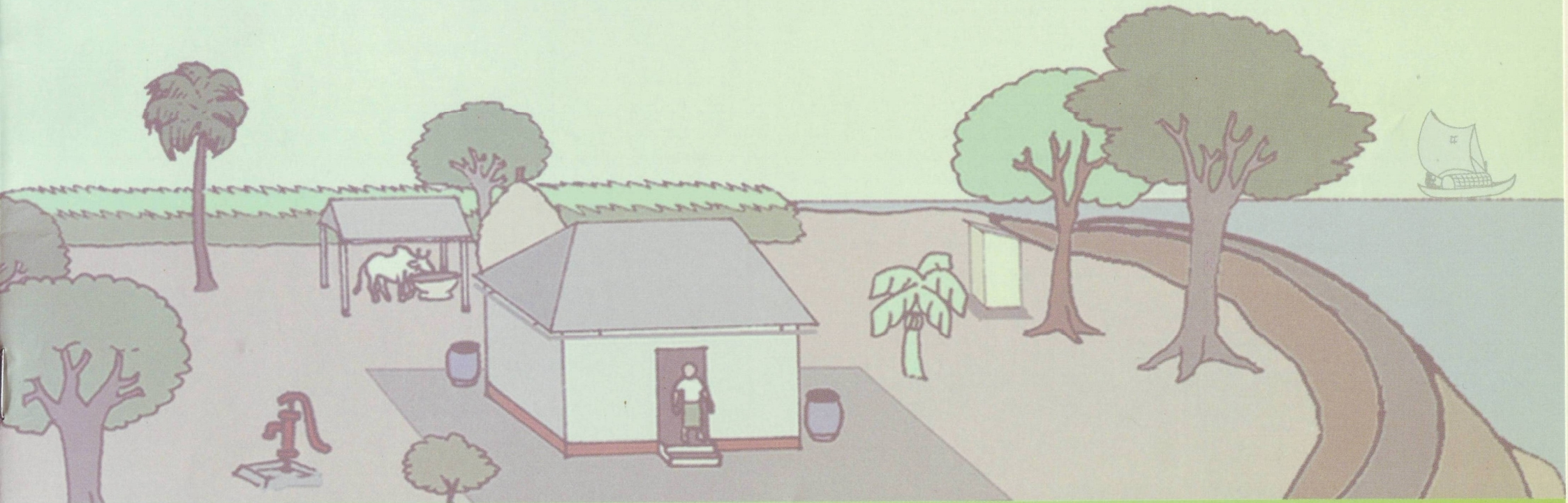


Construction Manual on

# Shelters for Cyclone-Prone Coastal Areas of Bangladesh





Department of Civil Engineering, Bangladesh University of Engineering and Technology (BUET) takes pride for its contribution in editing the "Construction Manual on Shelters for Cyclone-Prone Coastal Areas of Bangladesh". Traditionally BUET have always played a leading role in disseminating engineering solutions to different problems the country has faced. Particularly in the construction sector Department of Civil Engineering has contributed in some milestone publications which are nationally acclaimed and accepted. This manual which has come in this thread is for non-engineered shelters in rural-coastal Bangladesh. I hope this publication will be useful in the reconstruction of the southern coast of Bangladesh devastated by the cyclone Sidr last year. The manual is an excellent example of collaboration among government, academia and international organizations. Such collaboration can ensure technically sound and locally acceptable implementation of internationally funded programs. I express appreciation and thanks to my colleagues Dr. Raquib Ahsan, Dr. Md. Mizanur Rahman and Dr. Mohammad Shariful Islam and also to Prof. Stefano T. Tsukamoto of EWBJ and Mr. Md. Abu Sadeque of DMB for their effort in preparing this manual. I strongly believe that such a joint collaboration will enhance the cooperation between intellectuals towards minimizing the sufferings of people in Bangladesh due to natural disaster.

Dr. Muhammad Zakaria  
Head, Department of Civil Engineering  
BUET



Sidr, a Category 4-equivalent cyclone, caused large-scale evacuations and damage. Though official estimates put the number of casualties at 3447 as of Nov. 20, 2007. Both Bangladesh and Japan are tropical cyclone-prone countries. Many engineers in Japan, after their experiences in severe cyclones, have been wishing to contribute to Bangladesh people affected by Sidr. It is therefore our great satisfaction that the Engineers without Borders, Japan (EWBJ), Disaster Management Bureau (DMB) of the Ministry of Food and Disaster Management (MOFDM) and the Bangladesh University of Engineering & Technology (BUET) collaborated in publishing "Construction Manual on Shelters for Cyclone-Prone Coastal Areas of Bangladesh" supported by the Japan Platform (JPF). With a number of clear illustrations of full details, the manual propose plans of shelters that can be constructed with locally available materials and technologies together with some rather ideal goals that we will work toward. Dissemination of the knowledge and technology will be an important key to the success in mitigating cyclone-inflicted damage. For shelters, the importance of programs such as those for training the trainers is to be advocated among us. Lastly, all EWBJ members would like to express hereby their sincere sympathy to the people affected by the devastating cyclone. It is our sincere wish that the publishing of this manual will accelerate collaborations beneficial for both Bangladesh and Japan.

Dr. Kazuo Konagai  
President  
Engineers Without Borders, Japan (EWBJ)

## Preface

On the fatal night of 15 November, 2007, cyclone 'Sidr' struck the south coast of Bangladesh with a wind speed of more than 220 km/h. The cyclone took away thousands of lives, damaged huge area of crop land, wiped away live-stocks and other means of livelihood. A great number of people lost their houses. According to UNSCG estimation a total of 1,470,419 houses were affected. Among them 563,967 houses were completely destroyed. Presently the biggest challenge for the surviving people in their struggle to take up their normal course of life is their need for shelters to protect them from the coming monsoon. International community and a number of NGOs have come forward to help the distressed people with commitments of building shelters.

After the cyclone, there have been a number of surveys conducted by teams comprising of members from Bangladesh University of Engineering and Technology (BUET), Engineers without Borders, Japan (EWBJ) and Japan Society of Civil Engineers (JSCE). From the field observations it was found that one of the main reasons for destruction of a great number of houses is poor construction practice in Bangladesh. Many houses lacked proper anchoring with the ground and many did not have adequate lateral bracing. Rebuilding of houses with the same construction practice will be least desirable. Different NGOs and other agencies have their own designs for building houses in the affected area. However, it will be extremely difficult for the local administration to monitor quality of construction based on different designs. The UN Shelter Coordination Group (UNSCG) in consultation with Public Works Department, Disaster Management Bureau and BUET came up with a uniform set of designs supposed to be adopted for building shelters in the Sidr affected areas. The conceptual designs are adopted in the present manual with some modifications.

The designs have been elaborated for understanding of ordinary people. Among the four designs proposed by UNSCG, construction steps of two of them are presented here pictorially so that local people may adopt them for their future construction. The design of steel roof truss is not elaborated since the construction of them would require some skilled workmanship. The present manual may be used for training purposes of the local masons and carpenters. Building of a large number of shelters can best be carried out by employing local masons and carpenters. The designs elaborated here are supposed to withstand wind gust but they are not resistant against storm surge. Thus these shelters should be built in areas protected by proper embankments. The construction manual based on the uniform designs is supported by EWBJ with guidance from the Japanese advisors. Printing of the manual has been funded by Japan Platform.

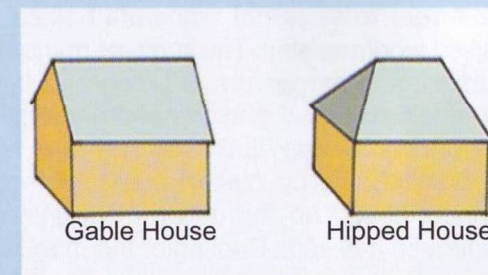
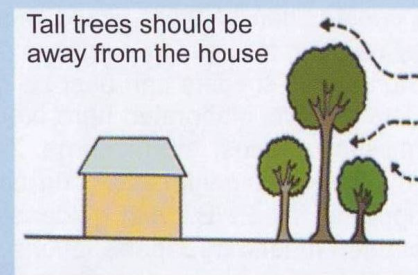
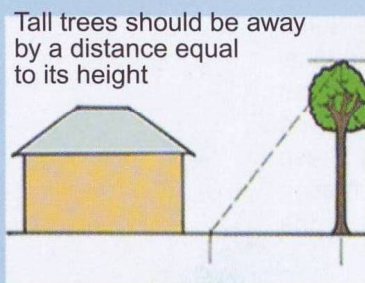
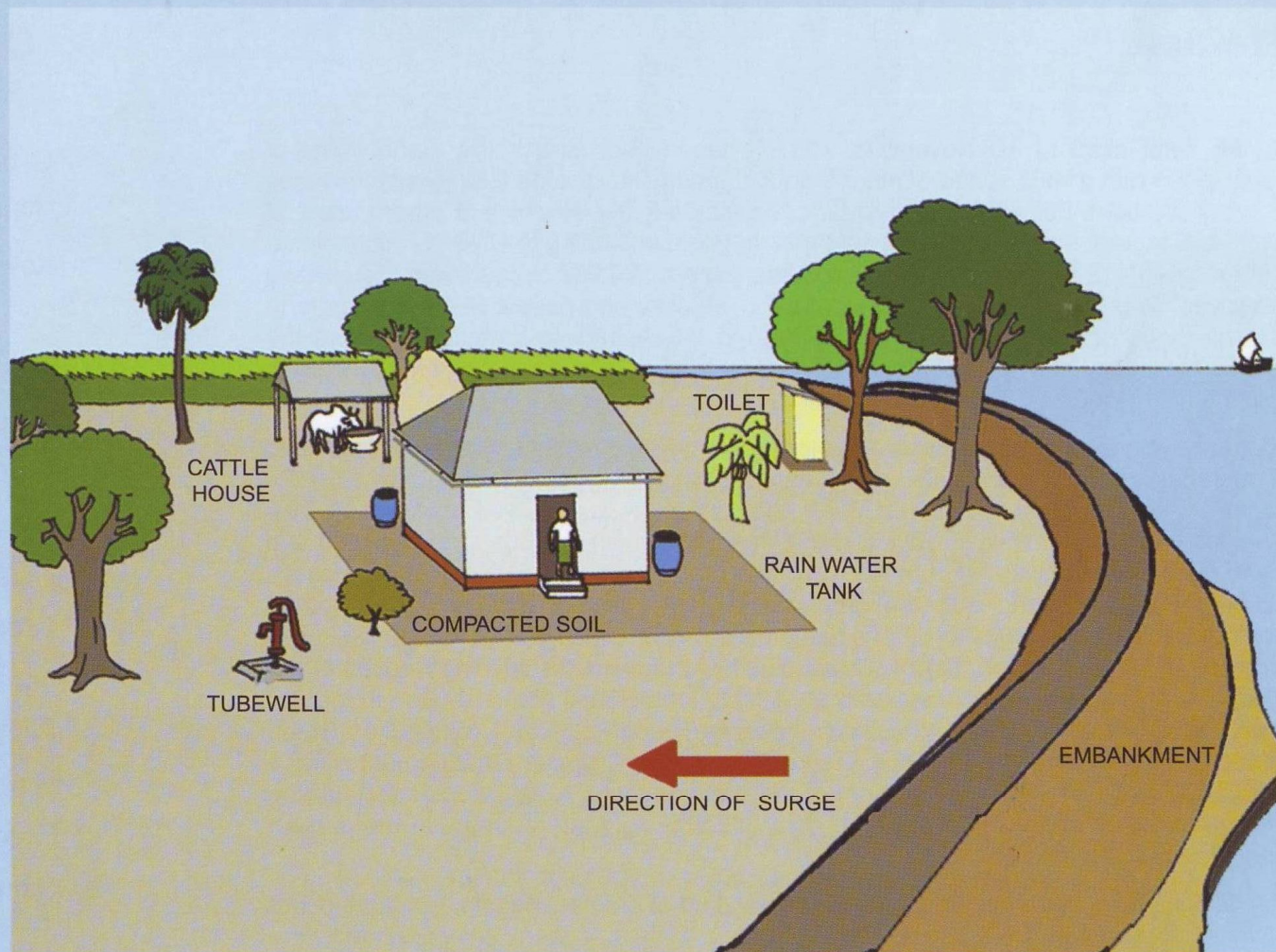
## Content

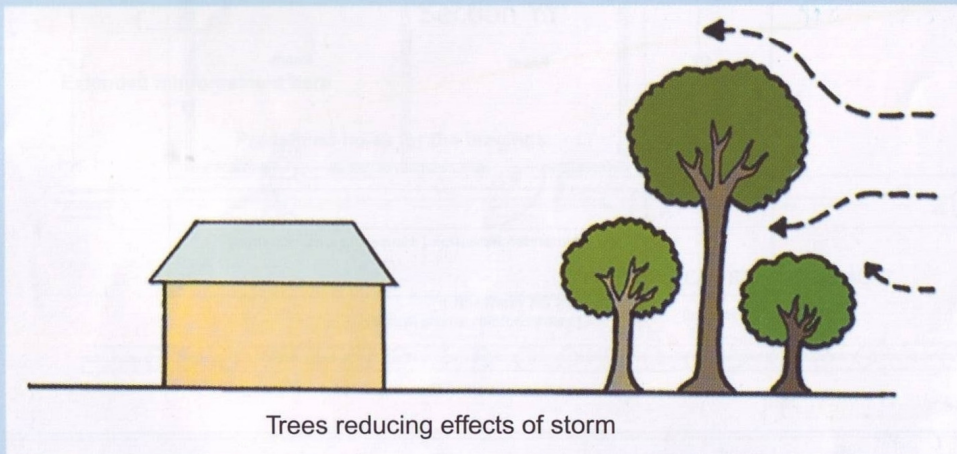
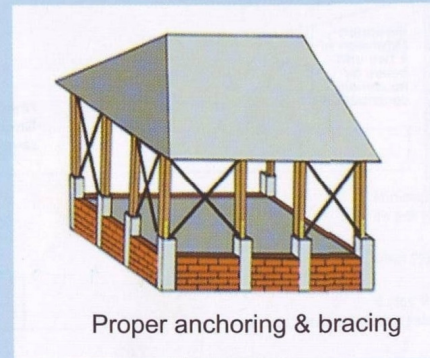
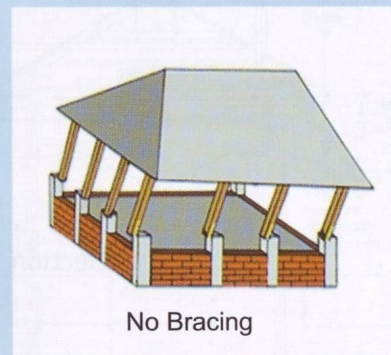
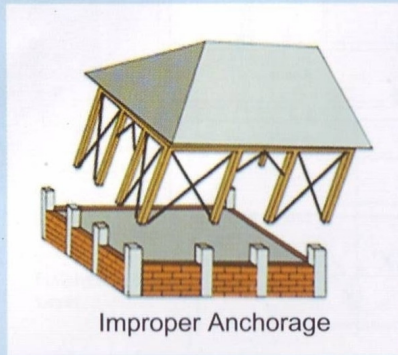
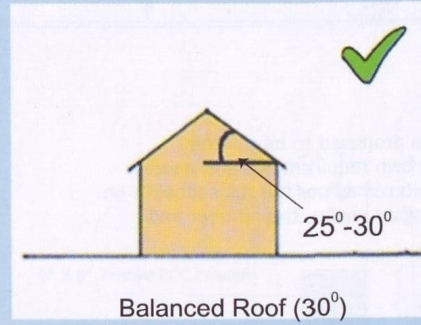
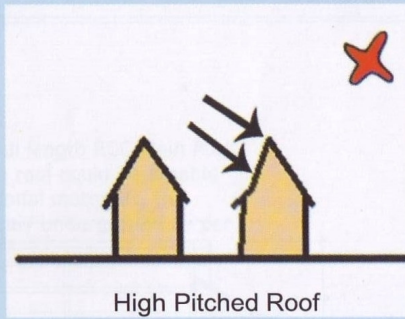
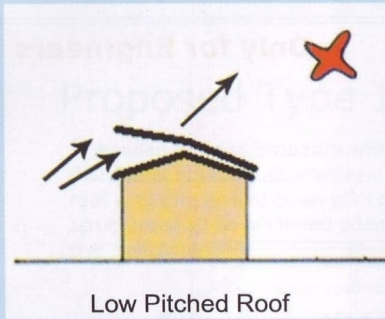
Overall Plan	2
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## Overall Plan

- If possible the house should be built inside the embankment.
- The shorter side of the house should be parallel to the bank of the river or coast of the sea.
- Construct the house on a raised and prepared plinth.
- Construct the house at a safe distance from the big trees. Safe distance means at least the distance equal to the height of the tree.
- Small trees like papaya or banana can be near the house.
- The tube well should at least be at a distance of 30 ft from the toilet and cattle house.
- A Hipped house is better than Gable house.
- There should be arrangements for rainwater harvesting. It can be very effective in case of emergency.



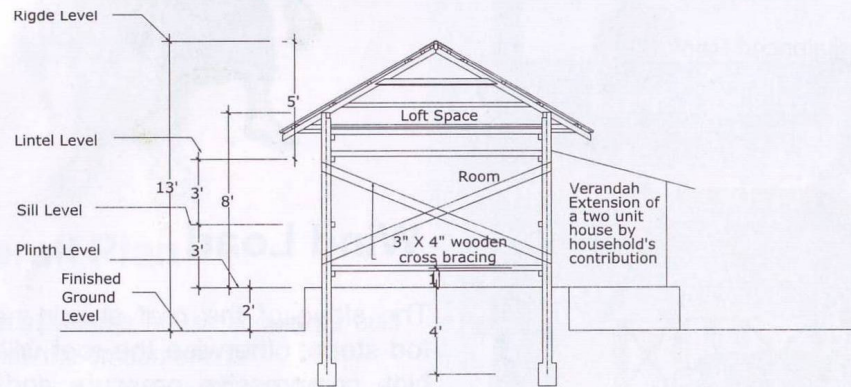


## Wind Load

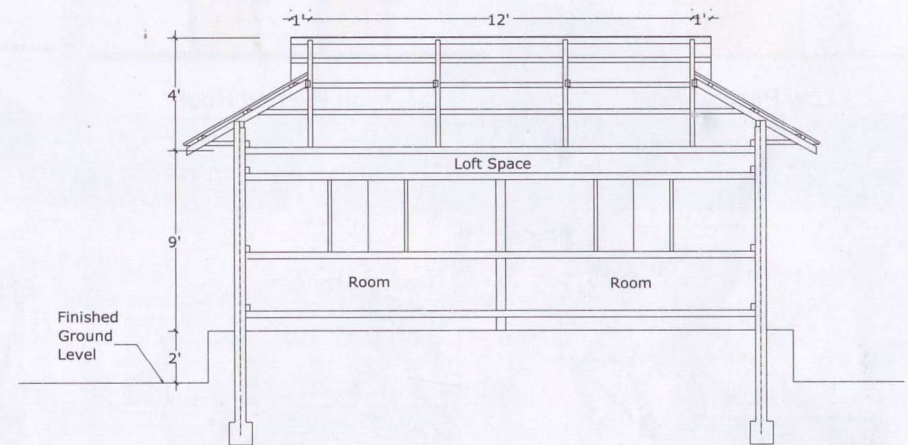
- The slope of the roof should not be too steep; otherwise the roof will face high compressive pressure and may collapse.
- The slope of the roof should not be too low; otherwise the roof will receive high suction and may blow off.
- To balance the wind load the slope should be within 25 to 30 degrees.
- The house has to be properly anchored to the foundation, otherwise the house may overturn.
- The frame of the house has to be braced and stiffened. A properly braced house is most likely to overcome a strong storm.
- Trees can act as shields for houses when they are built at a safe distance.

## Key Plan TWO UNIT HOUSE

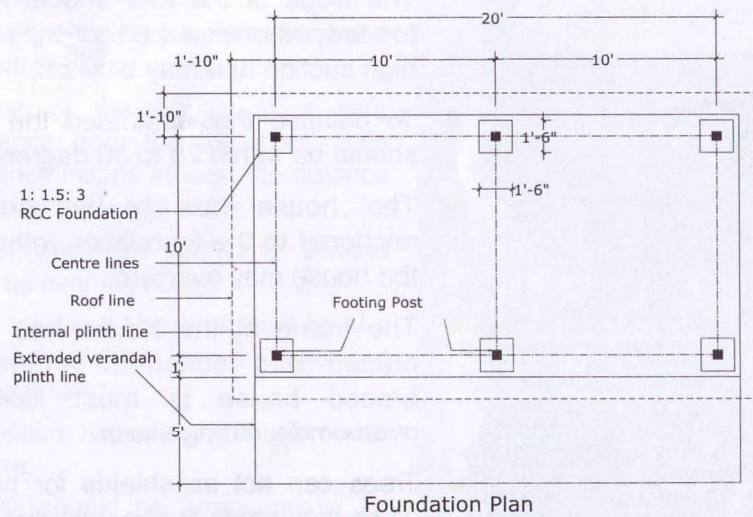
20'X 10' Two Unit House Plan the verandah extension is proposed to be the Household's contribution to the core house as per their own requirements and needs. The layout and the opening of the house may also be altered as per the Household's on site requirement with an approval from technical supervisor onsite, the number and locations of openings remains unchanged.



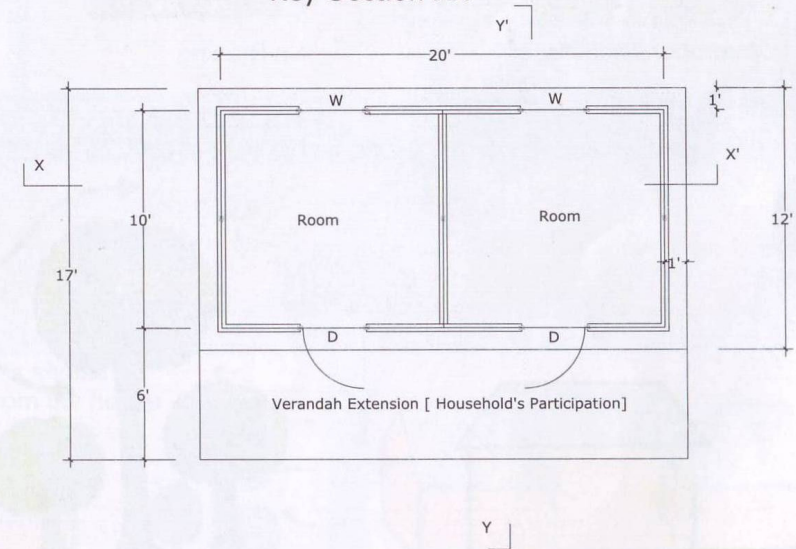
Key Section YY'



Key Section XX'

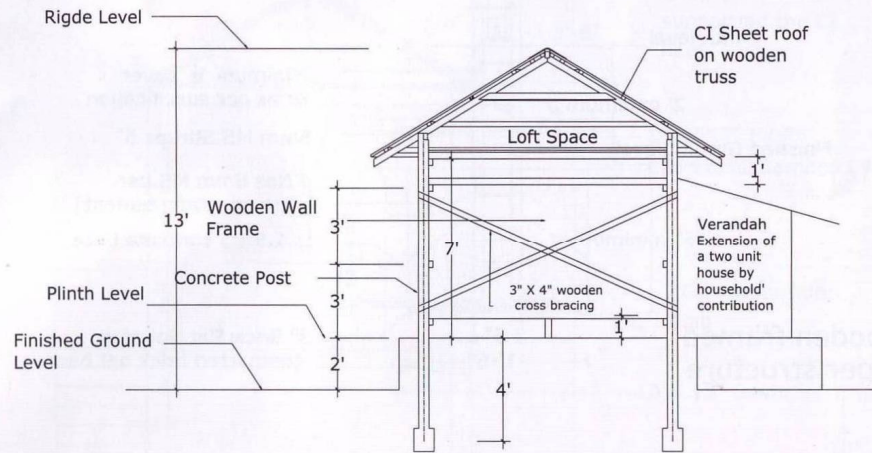


Foundation Plan

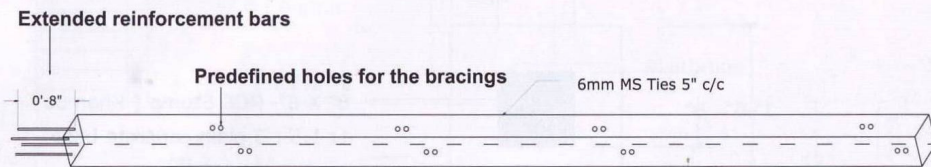


# Proposed Type 1

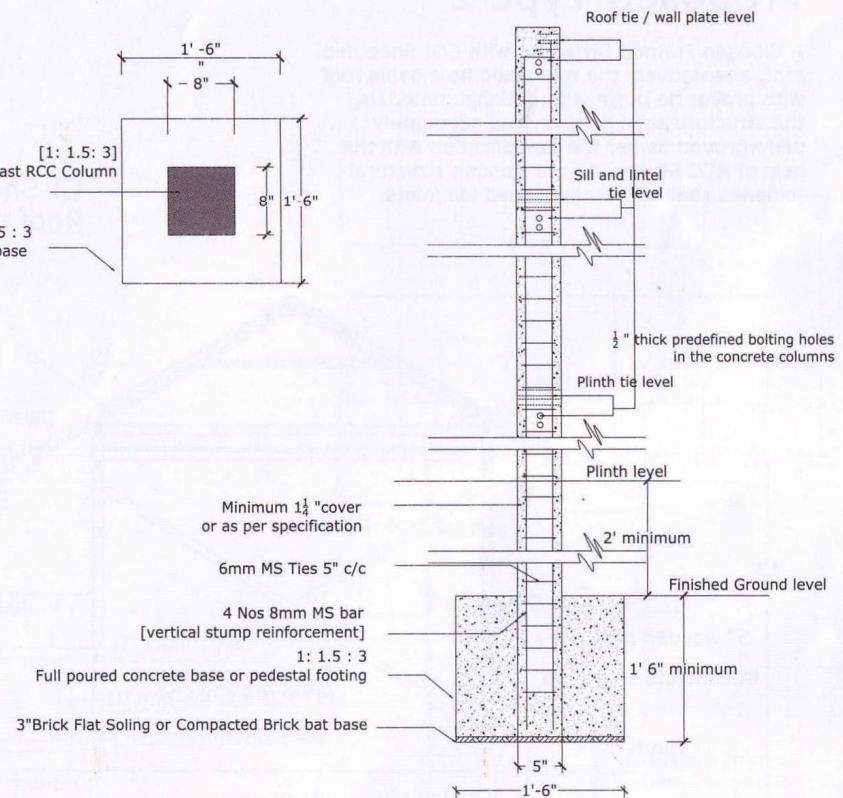
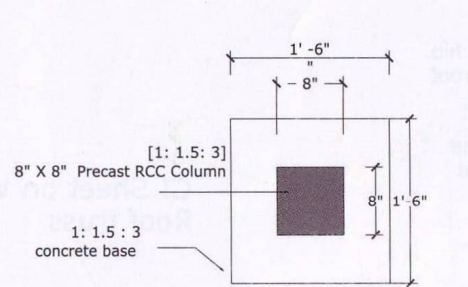
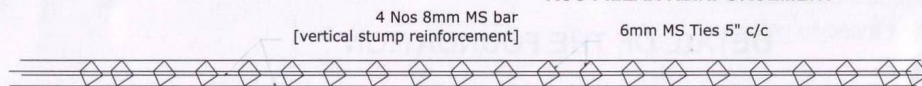
A Wooden Framed Structure with Full length RCC Main Post, CGI Sheet hip roof, alternatively the roof could be a gable roof with proper tied down with optional materials, the structure shall be anchored adequately underground as per the specification .



Section YY'



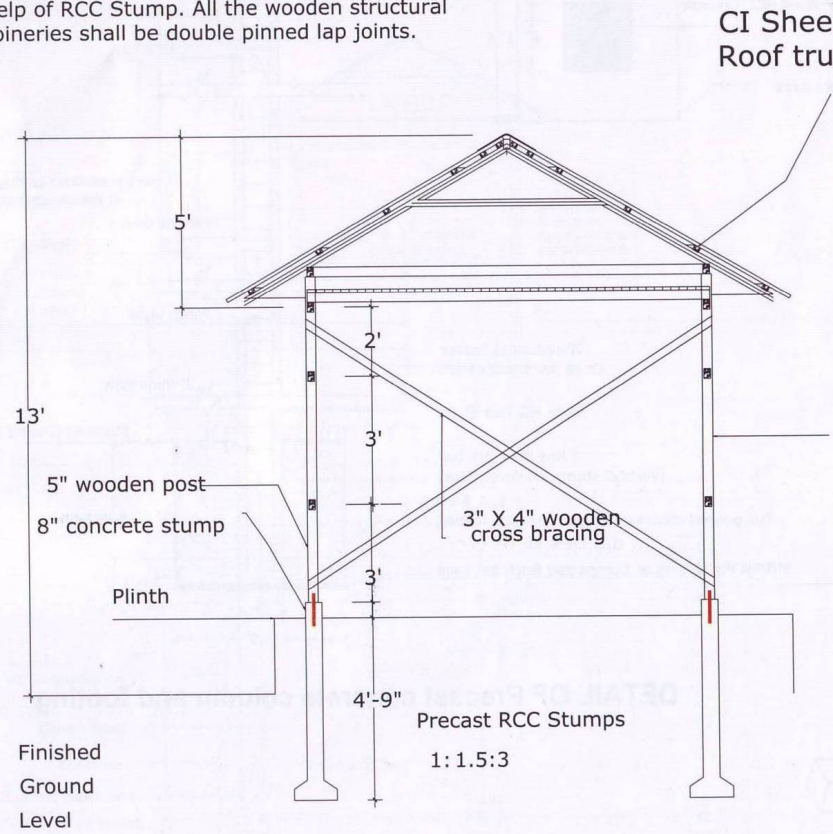
### RCC PILLAR REINFORCEMENT



DETAIL OF Precast concrete column and footing

## Proposed Type 2

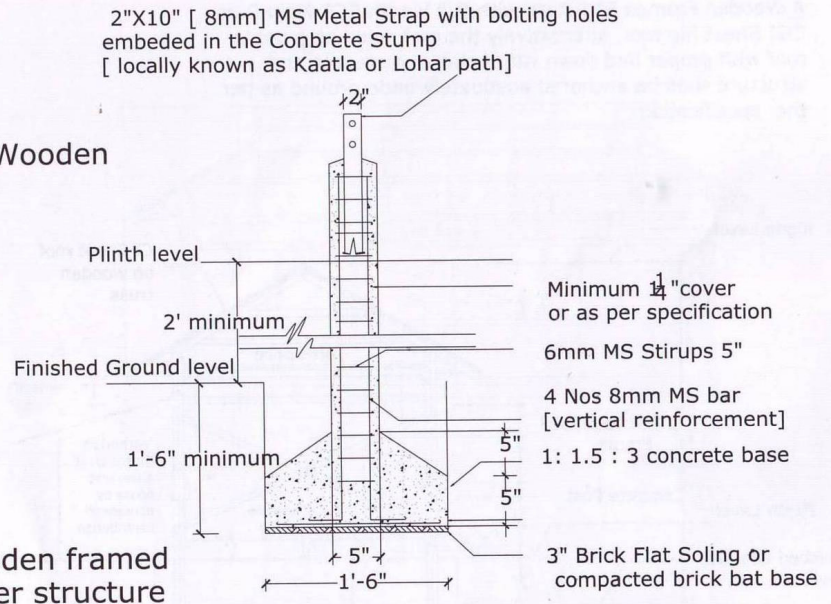
A Wooden Framed Structure with CGI Sheet hip roof, alternatively the roof could be a gable roof with proper tie down with optional materials, the structure shall be anchored adequately underground as per the specification with the help of RCC Stump. All the wooden structural joineries shall be double pinned lap joints.



Section YY'

CI Sheet on Wooden Roof truss

Wooden framed Super structure

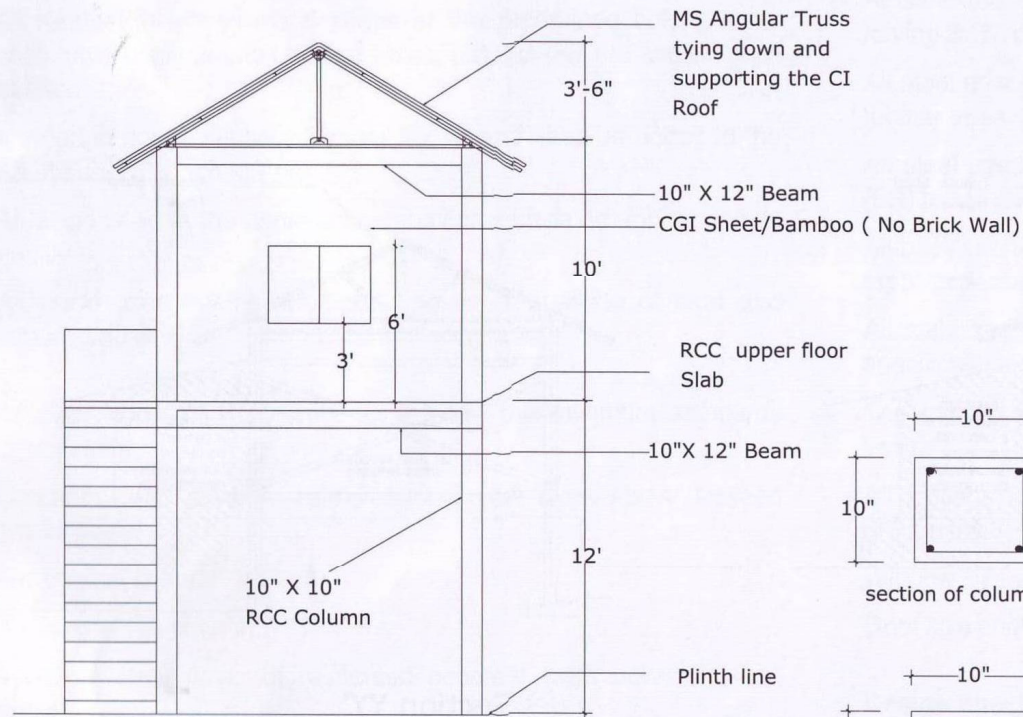


DETAIL OF THE FOUNDATION

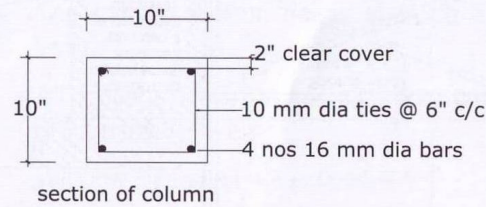
Only for Engineers

## Proposed Type 3

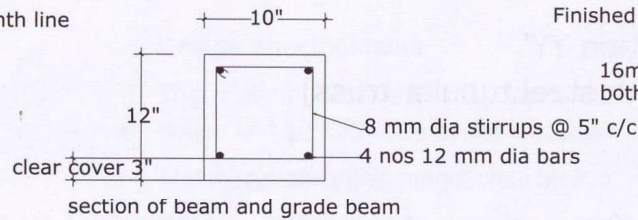
RCC Framed Stilt Structure raised 12' above GL with CI Sheet roof on steel roof truss, designed as a multi hazardous long term rehabilitation solution



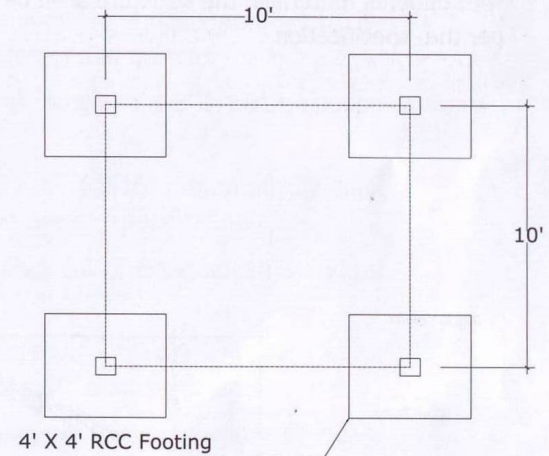
Elevation



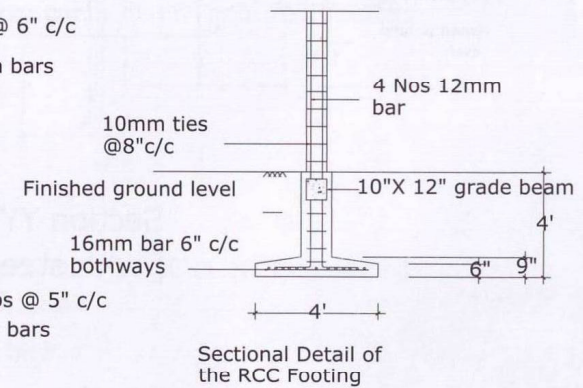
section of column



section of beam and grade beam



Foundation Plan

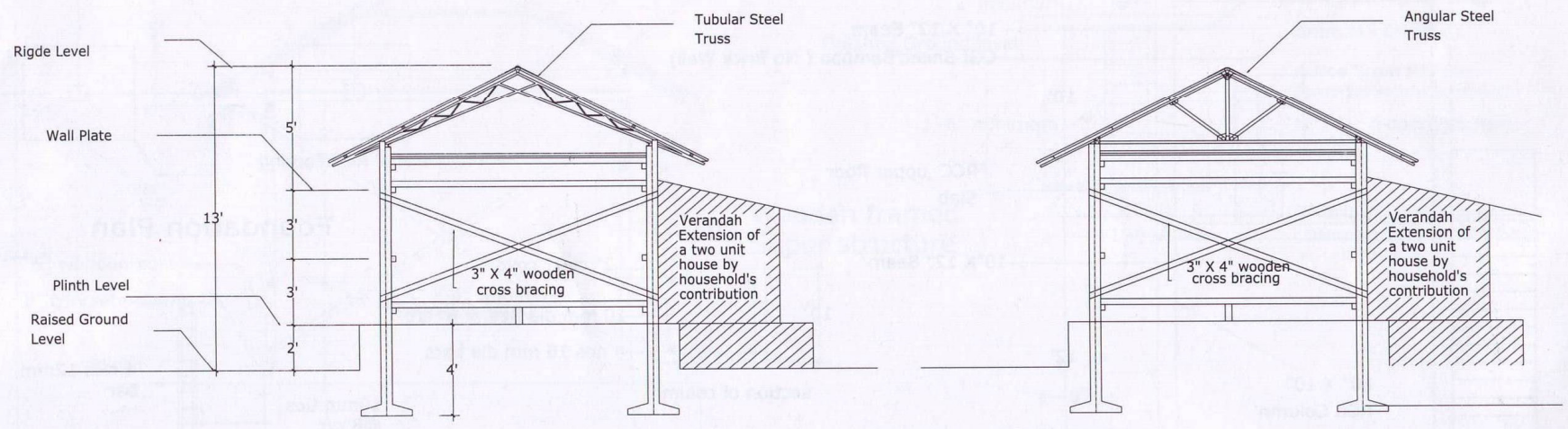


Sectional Detail of the RCC Footing

# Proposed Type 4

RCC Main Post, CGI Sheet hip or gable roof on MS steel truss with proper tied down with optional materials, the structure shall be anchored adequately underground as per the specification .

Only for Engineers



Section YY'  
[ with steel tubular truss]

Section YY'  
[ with steel angle truss]

# Structural Specifications

All wooden post shall be mounted on 1:1.5:3 RCC Stump with minimum 10" long standards Kaatla/ metal strap, or predefined bolting holes which ever is feasible best in the local context.

The Minimum cover around the wooden post and the edge of the concrete stump shall be 1 "

All Kaatla/Embedded metal straps or the predefined bolting joints shall have minimum two bolting holes, size as per the specification of the column

A wooden post shall be minimum 5"X 5" and shall be bolted to the Kaatla using ½ inch MS bolt

All wood used in the construction shall be of treated and seasoned quality

All wood used for the structural framework shall be of hard and matured quality.

All clear cover of RCC work shall follow the minimum standards specification:

Minimum clear cover of reinforced concrete work above finished ground level

For precast column: 1 ¼"

For cast in situ column: 1 ½"

Minimum clear cover of reinforced concrete work below finished ground level

For precast column: 1 ¼"

For cast in situ column: 2"

All openings doors and windows shall be placed minimum 2' from the corners

All wooden wall plates shall be minimum 4"X3" section

All wooden purlins shall be 2"X 1 " and spaced 1m c/c

All wooden principal tie shall be 4"X 3" cross section

All CGI Sheet shall be tied adequately to the superstructure by galvanized J hook or any other recommended device

All steel roof truss shall be made of minimum 1.5"X 1.5" L-section having 3/16" thickness

All steel principal ties shall be [ L 2"X 2" X 3/16" ] Alternatively steel tubular truss may be used as per the design specifications

All steel used in the construction shall be of Bangladesh standard (BS) made and approved quality.

All brick fortified plinth shall have minimum (1:4) cement ratio mortar for 5" thick masonry work and (1:6) for 10" thick work.

All stabilized earth plinth work shall follow the minimum standard specifications

The minimum plinth height shall be 2 ft from the finished ground level.

All footings shall have a minimum depth of 1'6" from the finished ground level

Window size shall not exceed 4'X 4'

Door size shall not exceed 3' 6" X 6' 6"

## Design Specifications

The minimum covered living space shall be 10' X 10' for one unit house and 10'X20' for a two unit house.

The minimum ceiling height shall be 8'

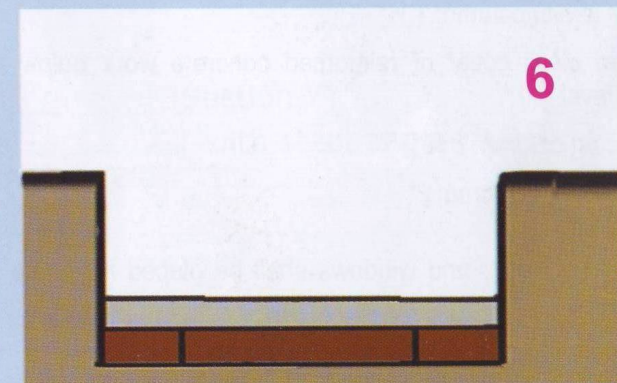
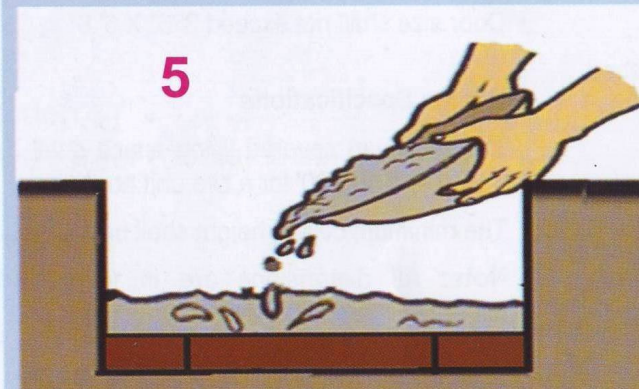
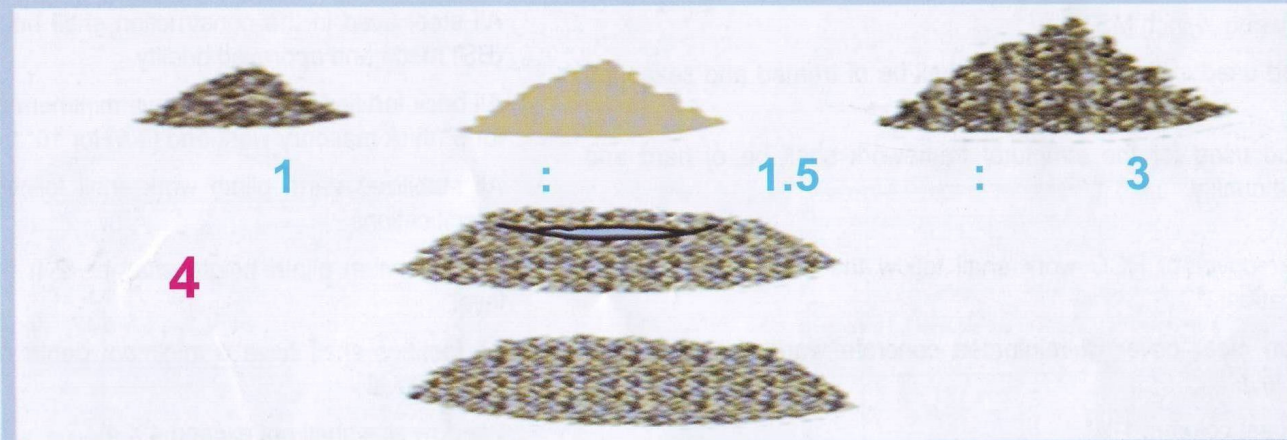
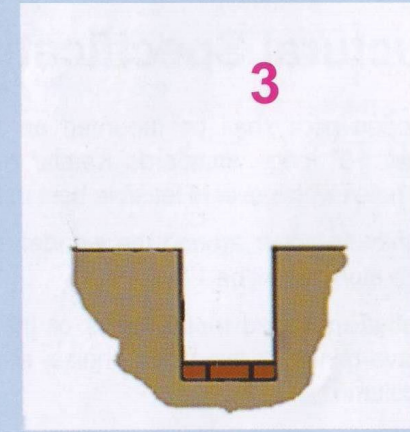
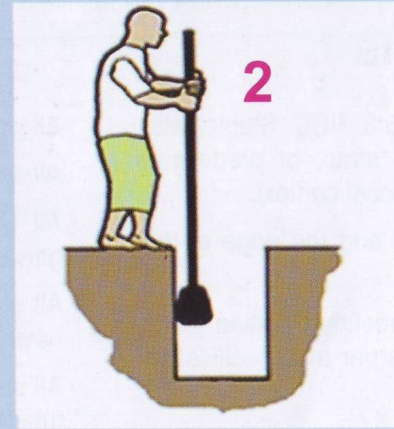
**Note:** All dimensions are in foots and inches; only written dimensions are to be followed.





## Footing General Steps

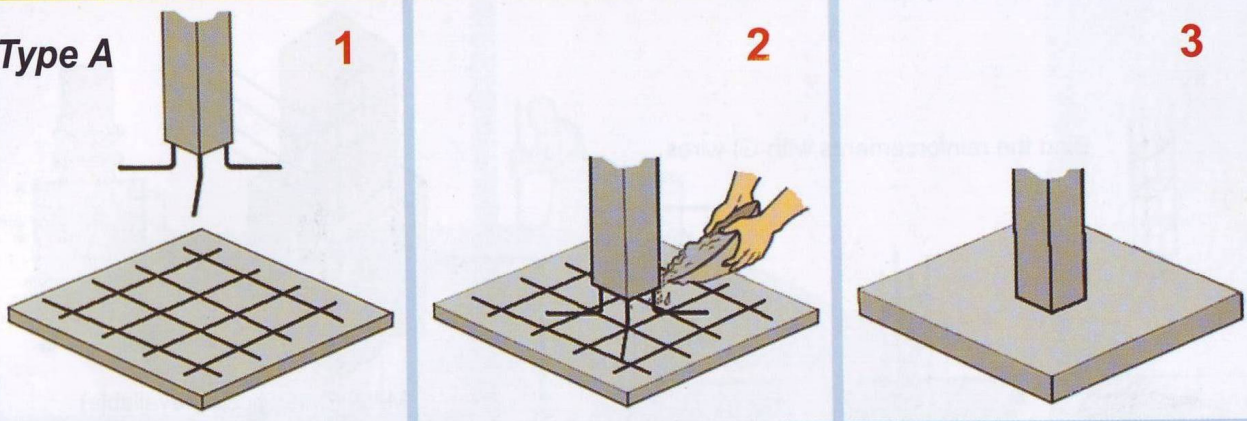
- Dig a hole 2 feet in depth and 18" X 18" in section.
- Compact the base with a ram.
- Place a brick flat soling of 3 inch thickness.
- Prepare a concrete mix at a ratio of 1:1.5:3. That means 1 part of cement and 1.5 part of sand has to be mixed with 3 parts of stone chips. The stone chips will preferably be 0.5 " down grade .For mixing use an amount of water just a little more than 1/3 of cement. Use non-saline water. Do not use too much water to increase the workability. The stone chips should be soaked in water before mixing.
- Pour the concrete mix inside the hole. The concrete has to be used within 45 minutes of mixing. Compact the concrete layer.
- Over this prepared base the next parts of the footing will be installed.



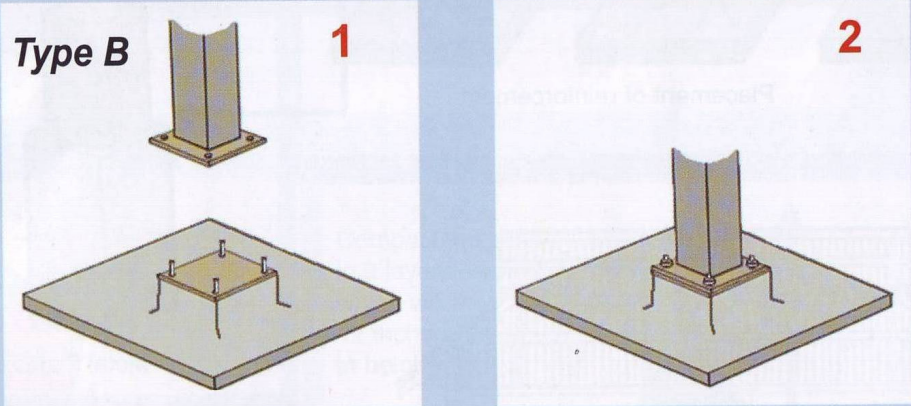


Follow these steps after following the general steps

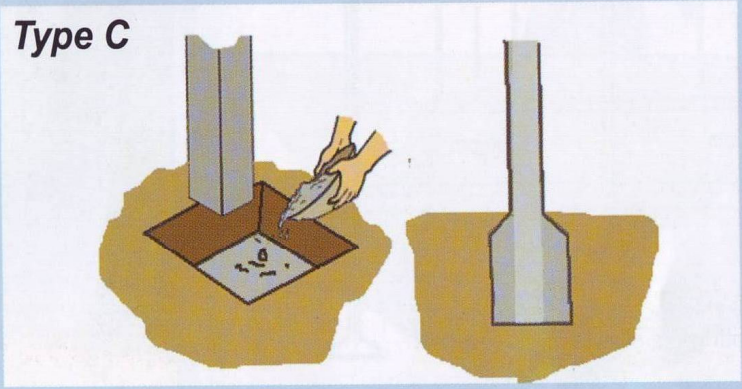
Type A



Type B



Type C



## Footings for Pre-cast RCC Posts

Three types of footings may be used

### 1. Type A

The pre-cast post will have extended bars. They will be bent according to the picture. Place the post over the concrete bed. Pour more concrete so that the anchoring bars are embedded in concrete.

### 2. Type B

Cast 18"X18"X3" concrete with a bearing plate. The bearing plate will be attached over 3" raised base. The plate should be well anchored into the concrete. The pre-cast RCC post shall have a plate attached to its base. Then connect them using bolts.

### 3. Type C

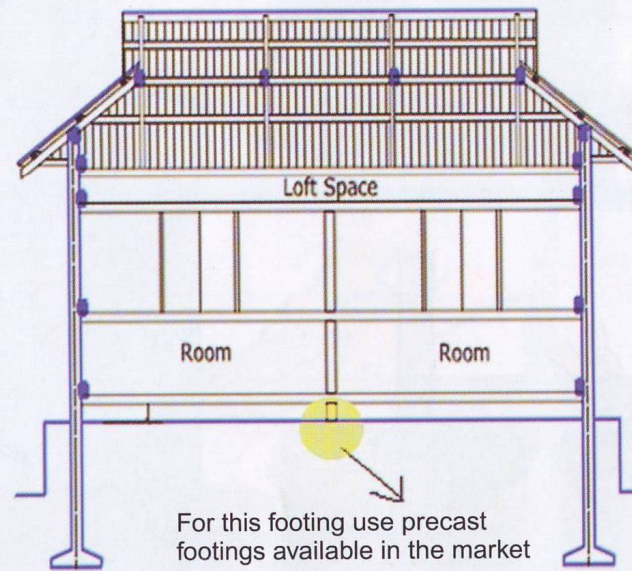
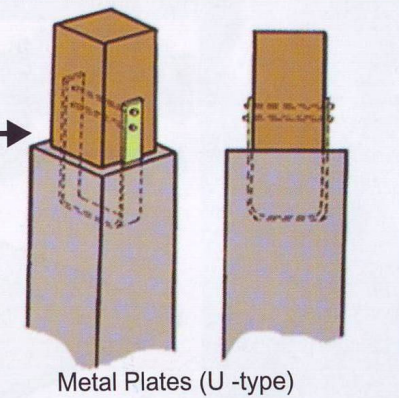
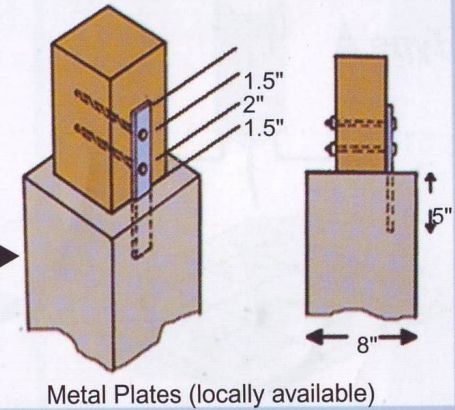
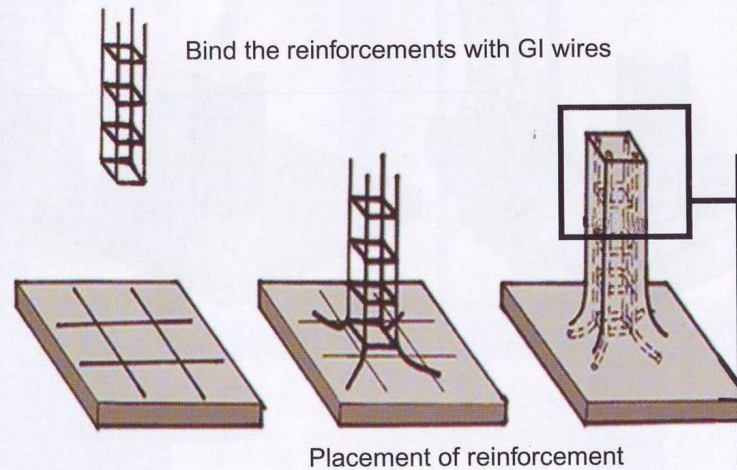
Dig a hole 2 feet deep and 15" X 15" in section. Place the pre-cast RCC post vertically over the base and pour concrete around the post according to picture.



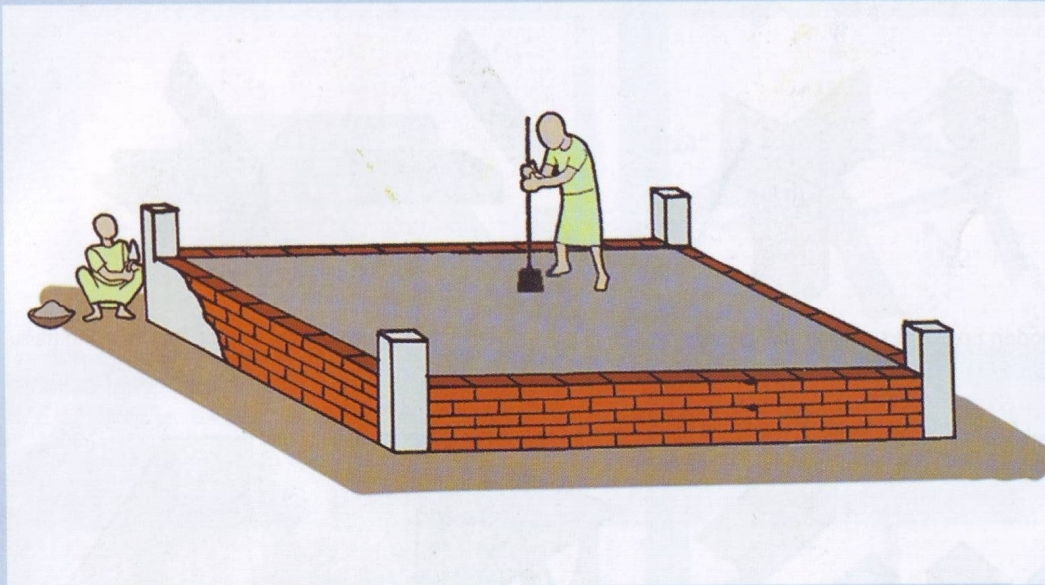
## Footing for wooden posts

- Concrete stump up to the plinth level will be provided as the footing for the wooden post. It will be at least 8 inch X 8 inch in section. During concrete casting a 10 inch MS flat bar with two 1/2 inch dia hole will be inserted vertically. A plumb bob may be used to maintain the verticality. At least 5 inches of the flat bar has to be embedded in the concrete.
- U shaped flat bars are stronger than single flat bars. The wooden post should be connected to the flat bar with nuts and bolts. Preferably drill machine will be used for making holes in the wooden post. The flat bar should preferably be made of galvanized iron otherwise it has to be painted. It is important for protection against the salinity of coastal atmosphere.
- For the posts, except for the corner ones, pre-cast footing may be used. It will be at least 6 inches X 6 inches in section. These are available in the market.

Follow these steps after following the common steps

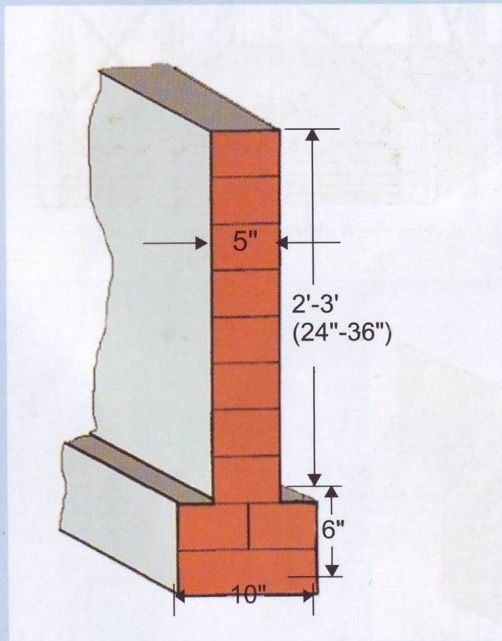


Pre-cast footing available in the market

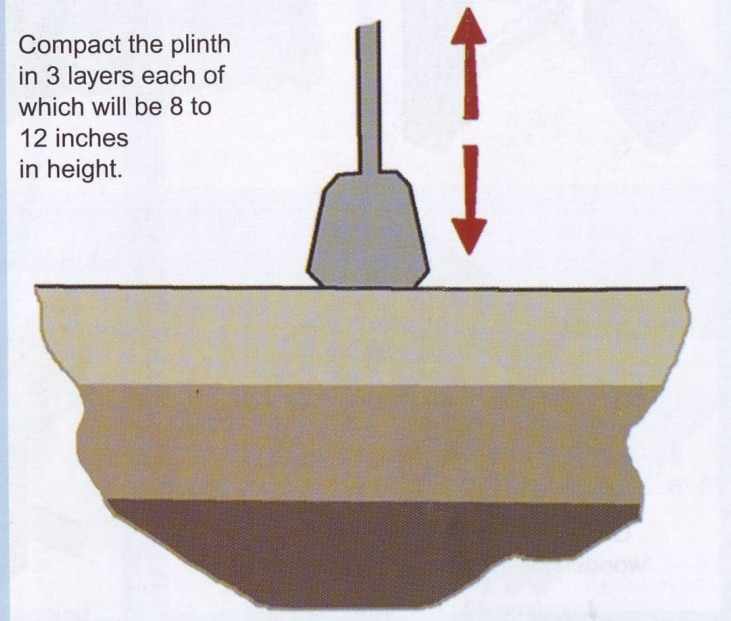


## Plinth Preparation

- Plinth has to be a raised platform, preferably 2 to 3 feet higher than ground level.
- 5" brick wall (with cement mortar 1:6) should be provided around the plinth. The wall should preferably be supported by 15" base.
- All the bricks for the masonry works should be soaked in water at least 6 hours before the work.
- The soil of the plinth should be compacted. Place the soil in layers. Each layer should be 1 foot in height. There has to be 12 blows of the ram for each square foot.
- The adjacent area (2 to 3 feet) of the plinth has to be compacted too.



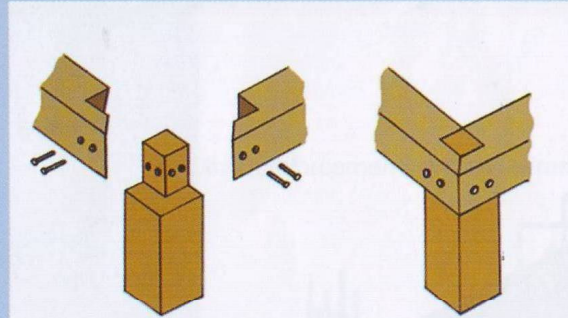
Compact the plinth in 3 layers each of which will be 8 to 12 inches in height.



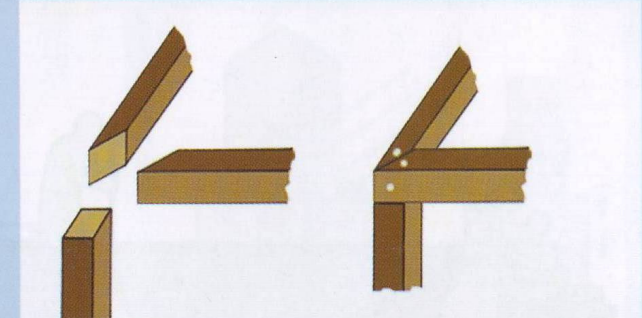


## Frame Structure

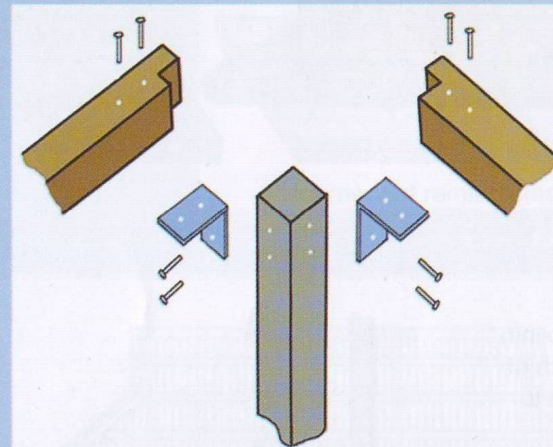
- All the beams and atleast the interior columns should be made of timber. The outer columns may be wooden or concrete (pre-cast rcc).
- All the joints between beams and columns will preferably be connected by bolts. 0.5" dia MS bolts should be used.
- The joints may also be connected by nails. Bolted joints are preferred because they are stronger.
- The spans between the columns should be strengthened by using braces. These braces should be connected by nailing.
- The wooden beam and the Pre-cast RCC posts should be connected by angles and bolts. (See the picture)



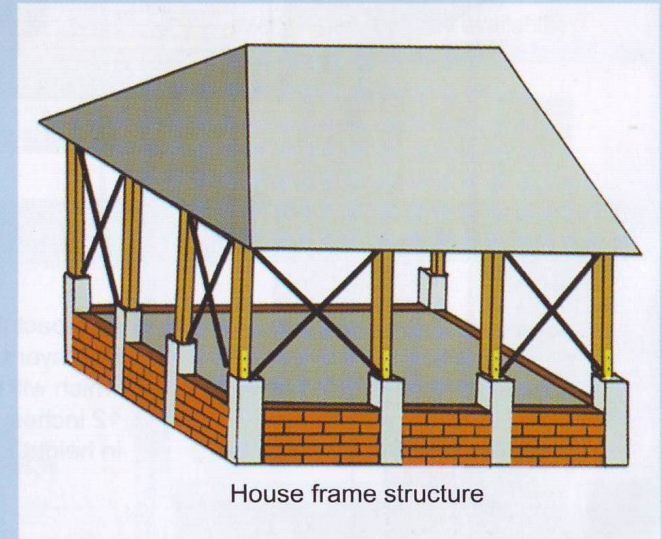
Connection for wooden posts and beams using bolts



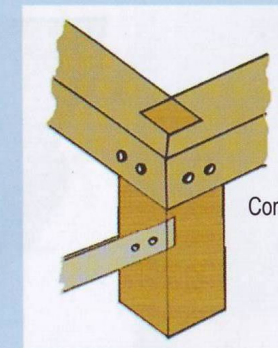
Connection for wooden posts and beams using nails



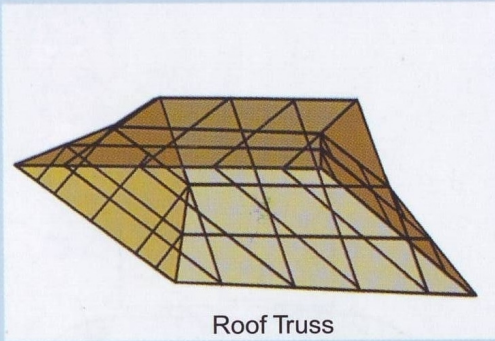
Connection for pre-cast column and wooden beams using angles and bolts



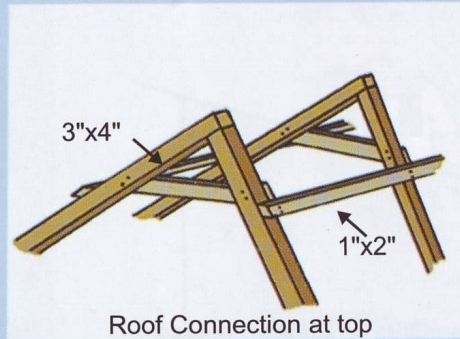
House frame structure



Connection of bracing



Roof Truss



Roof Connection at top



J Hook

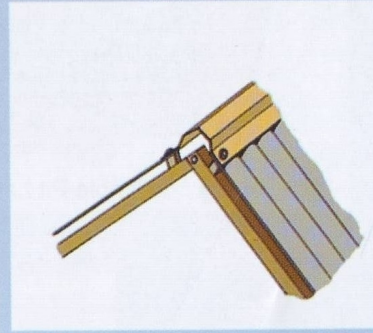
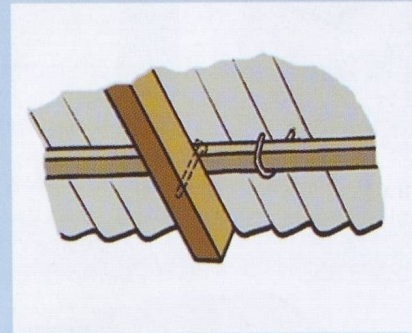
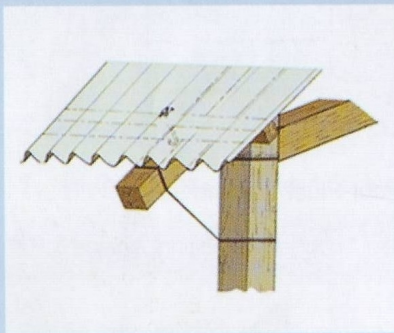


Washer

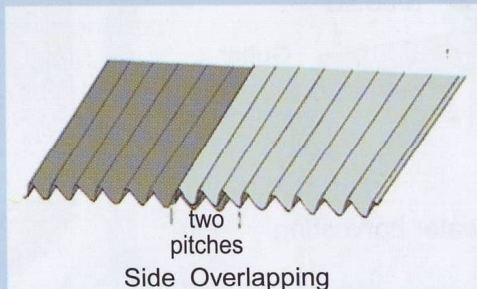


## Roofing

- The roof truss should be like the structure shown in the picture.
- All the components of the roof truss should preferably be made by timber.
- CGI sheets should preferably be used for roofing.
- J-hooks should be used to connect the CGI sheets with the purlin.
- For roofing the minimum thickness of the CGI sheet is 0.35 mm or 29 BWG and for side walls 0.29 mm or 31 BWG.
- There should be overlapping between the CGI sheets. The minimum side overlapping should be no less than two pitches and 6 inches on the longitudinal laps.
- The size of the washer should preferably be larger than 1" dia.



Connection between GI Sheet & Roof Structure



Side Overlapping



End Overlapping



## Sanitation & Water Supply

Any of the following types of latrines can be used

### Pour flush latrine

This latrine has ring slabs for confinement. It has a water seal which makes this latrine more acceptable. But this latrine is more costly.

### Simple pit latrine

This is the most simple latrine. This has no water seal. The cost is the least. Needs more maintenance.

### Rainwater Harvesting

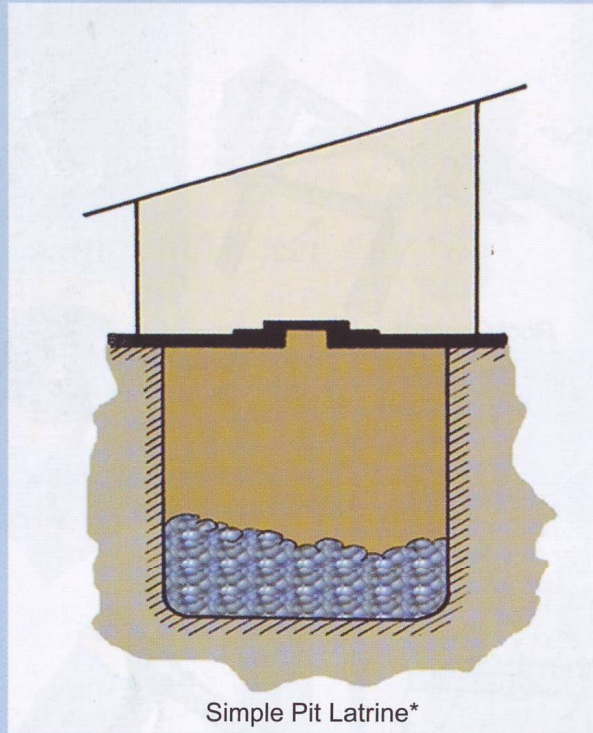
After the cyclone the supply of drinking water is hampered. In this situation rain water can be the best source of water. So, every house should have the provision of rainwater harvesting.

The gutter will be made by splitting a 4" PVC pipe longitudinally. The gutter has to be connected with the rafter by a bracket. The bracket will be connected by screws with the rafter.

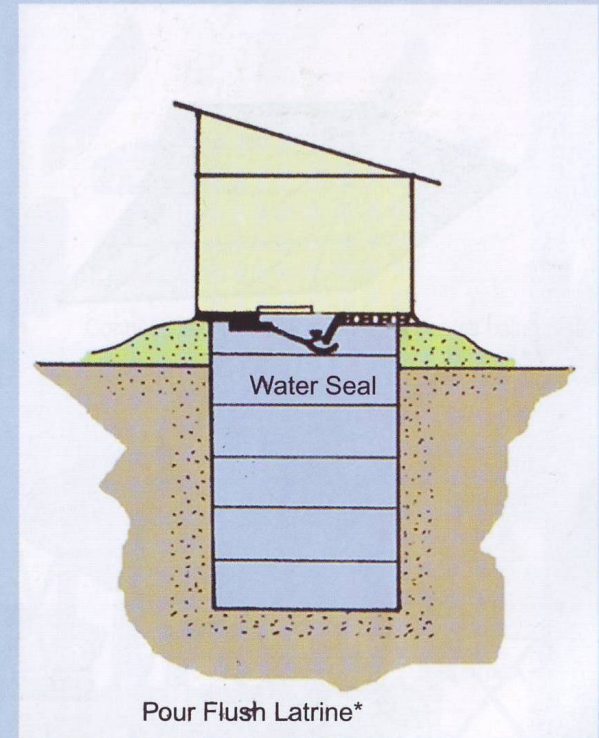
Keep the PVC drums closed upto 5 minutes from the start of rainfall.

There has to be some slope in the gutter, so that water can flow to the reservoir.

The reservoir (PVC drums) has to be rigidly installed in the ground.

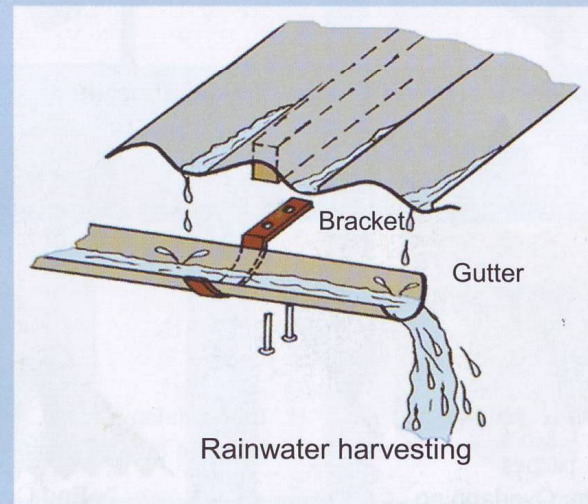


Simple Pit Latrine\*

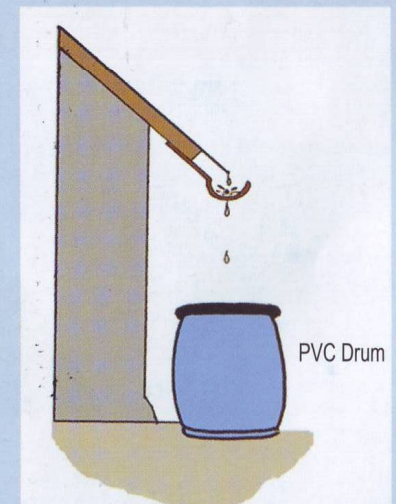


Pour Flush Latrine\*

(\* source : Water Supply & Sanitation, Ahmed & Rahman)



Rainwater harvesting



PVC Drum



## Is our house safe?

1. Is the house located inside the embankment?
2. Is the width of the house along the length of the river ?
3. Is the house at a safe distance from tall trees ?
4. Is there enough trees around the house ?
5. Is the tubewell at least 30 feet away from both the latrine and cattle house?
6. Has the plinth soil been compacted firmly?
7. Is there a strong connection between the post and the footing?
8. Is there any cross bracing within the house structure?
9. Is the CGI sheet connected firmly with a purlin?
10. Is the pitch angle of the roof within 25 to 30 degrees ?
11. Is the joints between wooden members strong enough?



## Instruction

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If the answers of these questions are **yes**, then you do not need to worry, your house is expected to be safe.

If any of the answers is **no**, then recheck and follow the instructions of this manual.

**Acknowledgement**

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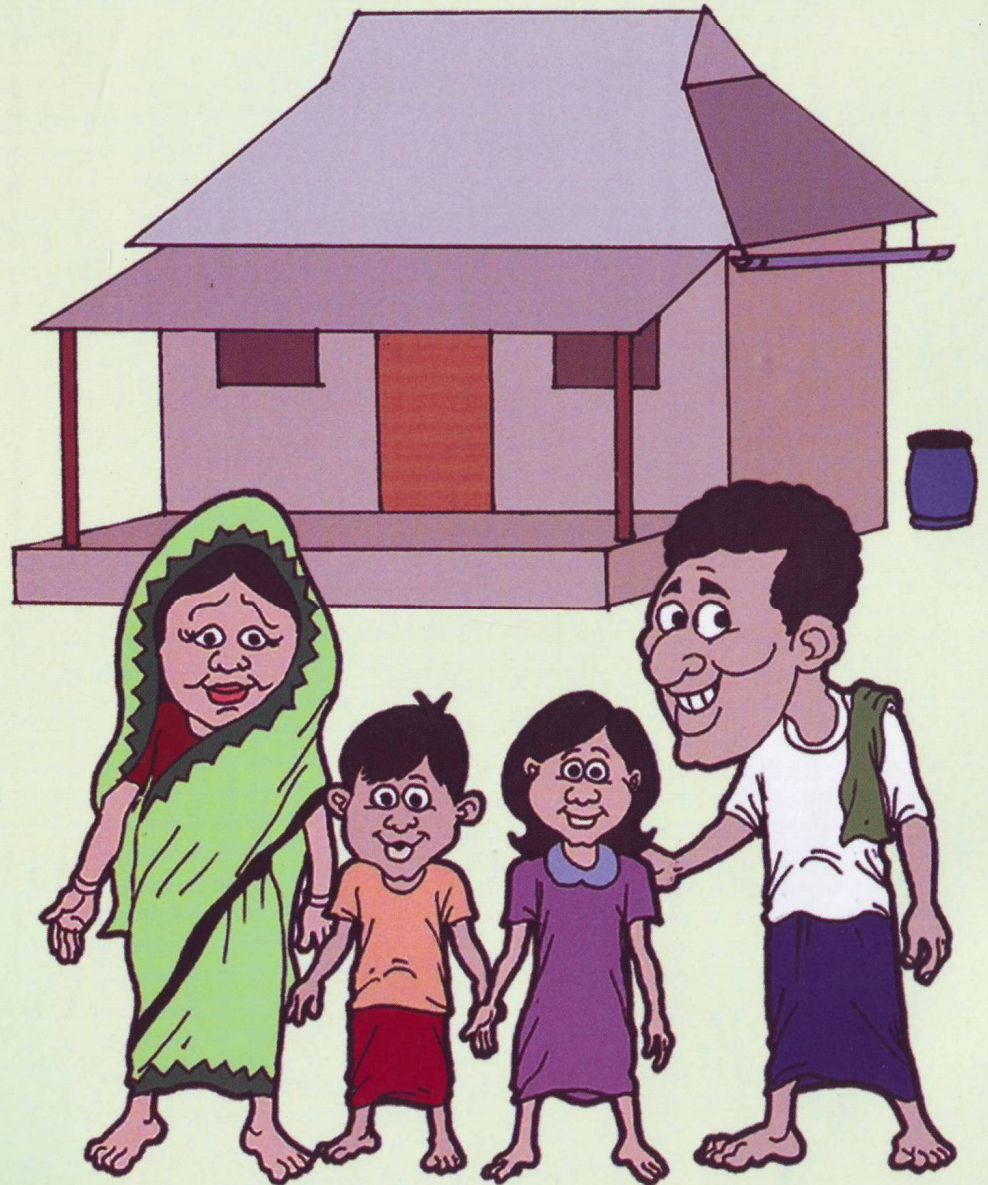
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